SiBEAM™
wireless beyond boundaries

A 4 Gbps Wireless True Uncompressed 1080p-Capable HD A/V Transceiver Using 60 GHz

HOT CHIPS 2007

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Imagine the full quality of a wired A/V connection for uncompressed high definition 1080p, coupled with the ease of use, ease of placement, and unified control capabilities of a fully interconnected wireless system.

This presentation will introduce the world's first chipset capable of achieving this using 60 GHz wireless transmissions.

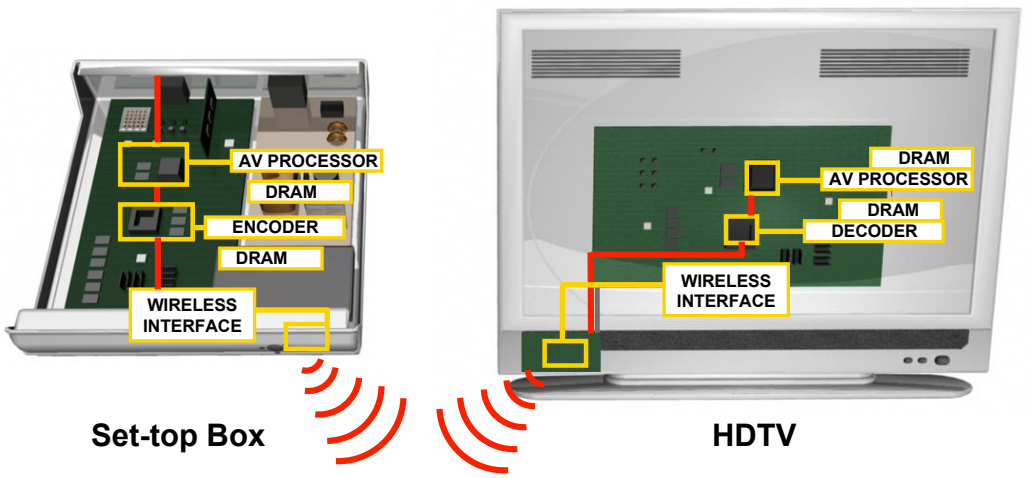
Agenda

- Benefits of Uncompressed High Definition Wireless A/V
- WirelessHD Overview
- Obtaining Very High Wireless Data Rates
- Challenges and Solutions for 60 GHz Operation
- Wireless Video Area Network Design
- SiBEAM's Uncompressed 60 GHz Wireless High Definition Chipset
- Conclusion

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Challenge of Compressed Plus UWB / WiFi

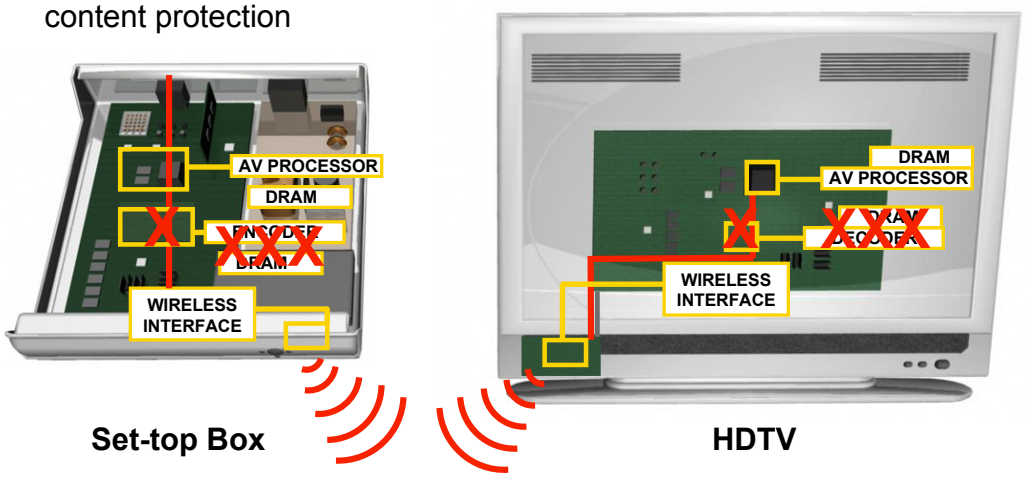
- Required encoder / decoder is significant system cost adder
- Impacted consumer experience – both latency and image quality
- Lack of standards – interoperability & content protection issues
- Interference with other 2.4 GHz, 5 GHz or UWB wireless solutions



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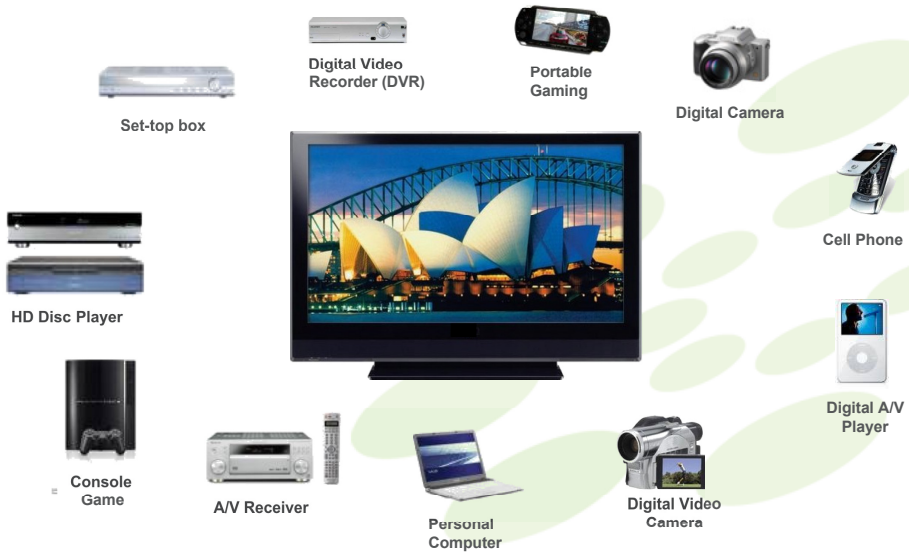
The Uncompressed Value Proposition

- Lower cost solution w/o video encoder & decoder
- Preserves best image and audio quality
- Avoids encoding generated latency
- No interference with 2.4 GHz, 5 GHz, and UWB wireless solutions
- Available WirelessHD specification for interoperability and content protection



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Enabling Wireless Video Area Networks



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Achieving Interoperability via the WirelessHD™ Consortium

Started in early 2005, seven market leaders and industry experts have joined together to create a special interest group, the WirelessHD™ Consortium, to develop an interoperable wireless specification for a wireless high-definition digital interface to enable a wireless video area network (WVAN) for high-definition baseband audio / video (A/V) streaming and high-speed media transmission for consumer electronics (CE) devices.

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WirelessHD Key Characteristics

- Interoperability supported by major CE device manufacturers
- High-speed wireless, multi-gigabit communications technology in the unlicensed 60 GHz band
- Uncompressed HD video, audio and data transmission, scaleable to future high-definition A/V formats
- Smart antenna technology for reliable, non line of sight (NLOS), high-quality consumer experience
- Device control for simple operation of consumer electronics products and network
- Secure Communications
- Quality of Service (QoS) for A/V applications

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Architecting a Multi-Gbps PHY

- Highest quality, low-latency HD content requires very high data rates
 - Uncompressed 1080p content requires raw data rates of about 4 Gbps at very low bit error rates
- This requires very high spectral efficiency or large amount of spectrum
 - Raw data rate = Spectral Efficiency (bps/Hz) * Bandwidth (Hz)
- Higher spectral efficiency leads to higher cost, less range and robustness
 - High spectral efficiency requires strong signals and complex processing
- Large amount of spectrum requires operation in a large (unlicensed) band
 - Multi-GHz unlicensed spectrum with reasonable Tx power available world-wide at 60 GHz
 - A better overall solution!

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60 GHz Advantage for High Data Rates

	Total Spectral Availability	Max Permitted Transmit Power (EIRP)	Max Data Rate	Bps / Hz Required to get to 4 Gbps (11a/g = 2.7)	World-Wide Availability
WirelessHD	7.00 GHz	8,000 mW (39 dBm)	~4,000 Mbps	1.6 bps/Hz w/ 2.5 GHz channel	Y
802.11n	0.67 GHz	160-3200 mW (22-35 dBm)	600 Mbps	100.0 bps/Hz w/ 40 MHz channel	Y
UWB	1.5 GHz – 7.5 GHz*	0.1 mW (-10 dBm)	480 Mbps	8.0 bps/Hz w/ 520 MHz channel	N

* Depending on geography

60 GHz makes cost-effective multi-gigabit data rates possible!

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Challenges & Solutions for 60 GHz Operation

- 60 GHz operation requires focused (directional) beams for high data rates at even moderate range
 - Result of Friis' equation, high carrier frequency, and required signal strength for high data rates:

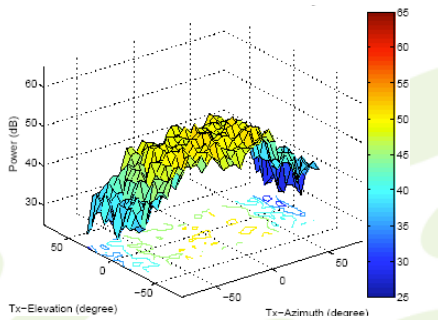
$$Power_{Rx} = \frac{Power_{Tx} \bullet Gain_{Tx} \bullet Gain_{Rx} \bullet c^2}{(4\pi \bullet Distance \bullet Frequency)^2}$$

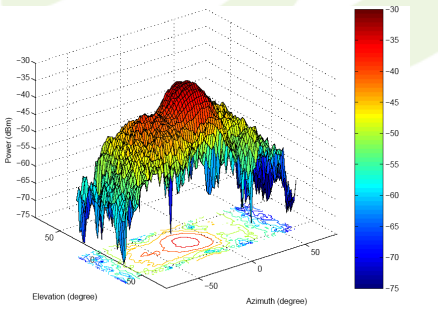
- Fixed "horn" antennas typically unacceptable due to required manual alignment and line-of-sight operation
- Dynamic "smart antennas" which electronically move a focused directional beam provide solution
 - An array of antennas are used to form an agile focused beam
 - Similar technology as radar - automatic operation - "just works"
 - Key component of SiBEAM OmniLink60 technology

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Real-Time Beam Steering Operation

- SiBEAM 60 GHz silicon, packaging, and real-time adaptive beam-forming algorithms enable non-line of sight streaming A/V
- Seamless dynamic adaptive beam-steering achieved – avoids obstacles while maintaining A/V stream
- Environment can be searched and optimal beam found in millisecond time scales
- Beam automatically adjusts if environment changes
- Omni-directional modes allow broadcast operation for device discovery and coordination





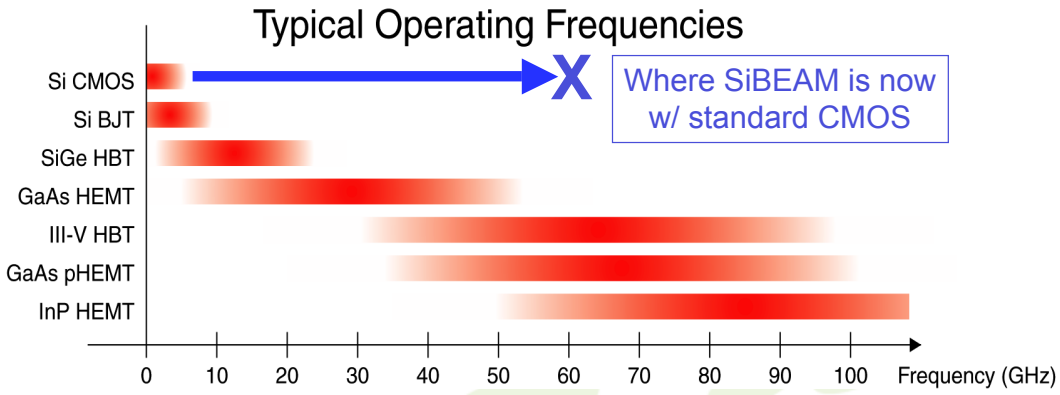
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Designing Cost Effective Smart Antenna Systems

- Large number of antennas (10 to 100) needed for the required antenna array gain
- Antenna size scales inversely with carrier frequency, resulting in millimeter-scale antennas for 60 GHz
- SiBEAM has developed micro array antenna design techniques to leverage standard packaging processes to fabricate antenna arrays on the same package that houses the 60 GHz circuits
- Cost-effective solutions require cost-effective circuit implementation

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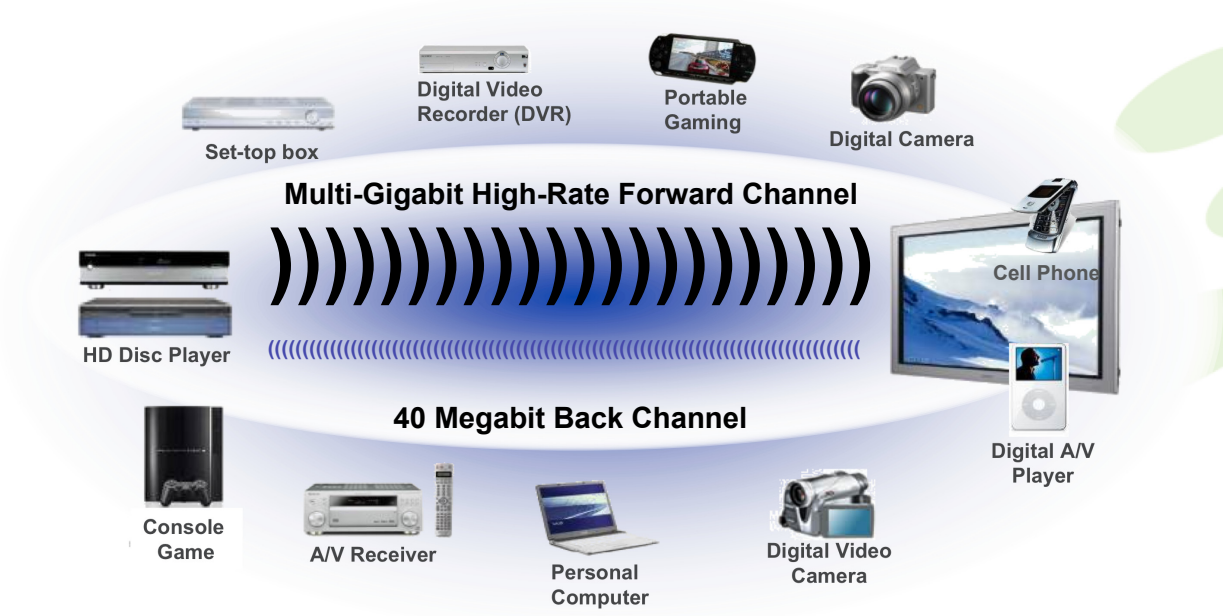
SiBEAM Breakthrough for Microwave CMOS



- CMOS offers enormous cost reduction while providing higher integration and reliability
- Each new process generation moves the frequency 20–40% higher
- SiBEAM's approach allows full use of the capabilities of the technology

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Wireless Video Area Network (WVAN) Topology



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PHY Provides Omni and High Throughput

Two types of Physical Layer (PHY) modes supported at ranges of 10+ meters:

- High-rate PHY (HRP):
 - Used for video and audio transmission
 - 1-4 Gb/s in beam-formed uni-directional mode
 - Supports uncompressed 1080p / 24 bit color @ 60 fps
 - Deep color capable enhancements
 - OFDM with QPSK and 16-QAM modulation
- Low-rate PHY (LRP):
 - Used for commands, beacon, broadcast and ACKs as well as audio
 - 2.5 - 10 Mb/s in omni-directional mode
 - 20 - 40 Mb/s in beam-formed uni-directional mode
 - OFDM with BPSK modulation

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A MAC Architecture Optimized for Streaming High Definition Content

- Streaming low-latency, high-quality HD A/V requires careful MAC design
 - Some standards such as 802.11 / WiFi are more data-centric
- Time-Division Multiple Access (TDMA) scheduling promotes better QoS
- Central Coordinator schedules the traffic for the WVAN
 - One of the devices present (typically a display in the network) automatically becomes the Coordinator
 - All devices receive periodic beacons from the coordinator indicating schedule to allow them to precisely time transmits and receives
 - Coordinator also tracks WVAN members' entry and departure
- All communications are direct between devices (not via coordinator)
 - Results in greater network efficiency and relaxes coordinator requirements

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Wireless Video Area Network Security

WVAN security is obtained on many levels:

- Proven strong encryption techniques
- Full digital content protection for Hollywood content
- Consumer content protection for user content and control
- Multi-Gbps uncompressed content to evade data capture
- 60 GHz & beam-formed communications for spatial containment
- Additional proximity controls

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Demonstration

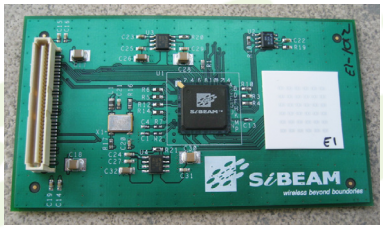
2-3 minute video clip demonstrating
60 GHz uncompressed 1080p WirelessHD prototyping system:



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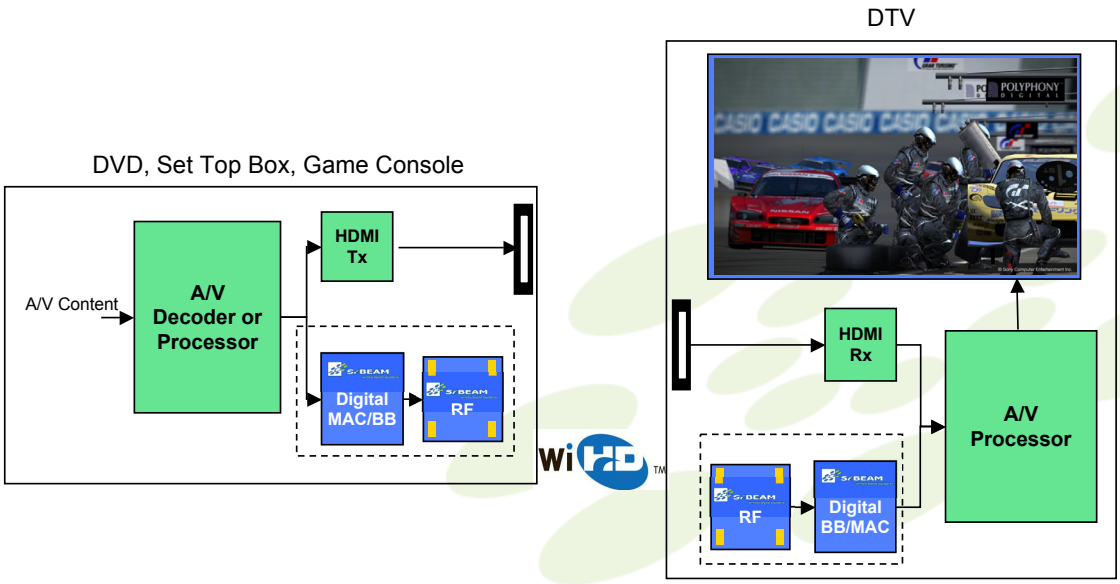
SOLUTIONS Technology & Performance

- Multi-Gbps data rate for *uncompressed* audio/video/data content
 - Reliable connections (wired equivalent < 10^{-10} BER)
- OmniLink60™ technology for non-line-of-sight A/V applications in 60 GHz band
- 1080p, 60Hz video at 10m
 - Deep Color support at 720p/1080i
- High performance 8-channel, 192kHz audio
 - PCM and compressed data formats
- Hollywood approved secure content delivery
- Low cost, low component count, small form factor module
 - Standard CMOS logic process for low cost
 - Innovative package technology simplifies design
 - Completely integrated element micro antenna arrays



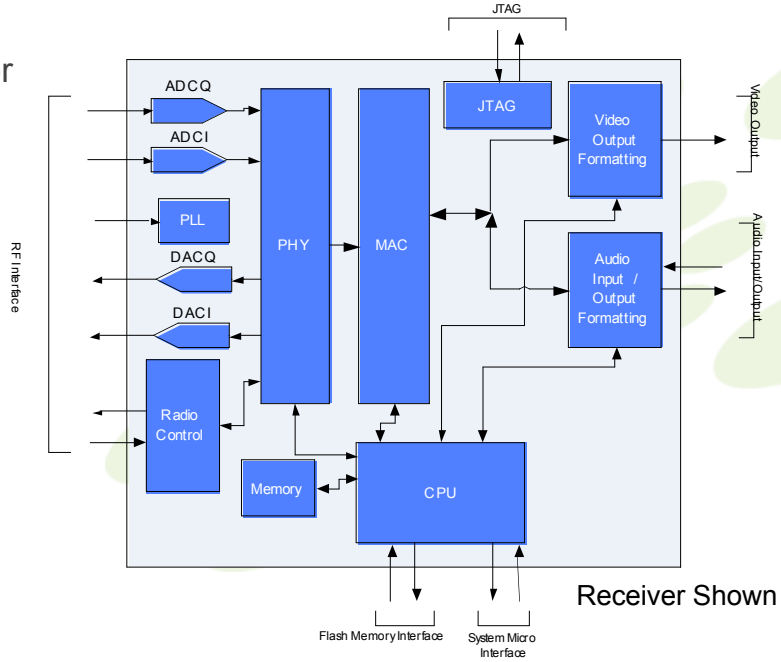
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SOLUTIONS Simplicity for Ease of Development



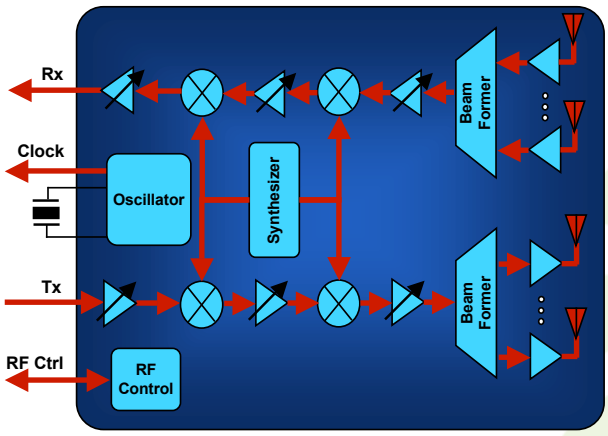
SOLUTIONS Complete Receiver Integration

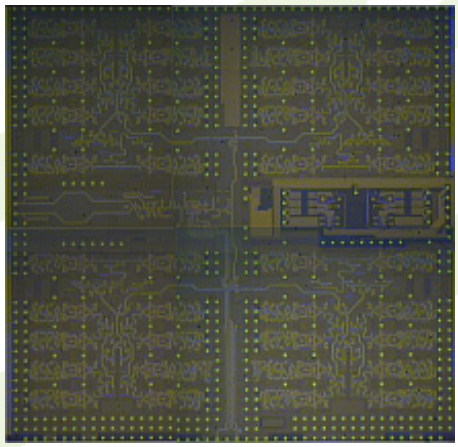
- Complete solution for WirelessHD system
- All WVAN control managed by embedded CPU
- Standard CE audio / video interfaces



Receiver Shown

RF Chip Block Diagram and Die Photo





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Conclusions

- Uncompressed high definition wireless A/V enables highest quality experience with reduced cost & complexity
- WirelessHD specification enables interoperability
- Very high wireless data rates possible through use of wide license-free 60 GHz band
- Robust non-line-of-sight (NLOS) operation possible through OmniLink60's™ smart antenna technology
- Wireless video area network allows central control
- SiBEAM's uncompressed 60 GHz wireless high definition chipset delivers "antennas-to-bits" integration

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